Dependence of Edge Turbulence Dynamics and the L-H Power Threshold on Toroidal Rotation\(^1\)
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The injected power required to induce a transition from L-mode to H-mode plasmas is found to depend strongly on the injected neutral beam torque and consequent plasma toroidal rotation. Edge turbulence and flows, measured near the outboard midplane of the plasma (0.85 < r/a < 1.0) on DIII-D with the high-sensitivity 2D beam emission spectroscopy (BES) system, likewise vary with rotation and suggest a causative connection. The L-H power threshold in plasmas with the ion $\nabla B$ drift away from the X-point decreases from 4-6 MW with co-current beam injection, to 2-3 MW near zero net injected torque, and to <2 MW with counter injection. Plasmas with the ion $\nabla B$ drift towards the X-point exhibit a qualitatively similar though less pronounced power threshold dependence on rotation. 2D edge turbulence measurements with BES show an increasing poloidal flow shear as the L-H transition is approached in all conditions. As toroidal rotation is varied from co-current to balanced in L-mode plasmas, the edge turbulence changes from a uni-modal character to a bi-modal structure, with the appearance of a low-frequency (f=10-50 kHz) mode propagating in the electron diamagnetic direction, similar to what is observed as the ion $\nabla B$ drift is directed towards the X-point in co-rotating plasmas. At low rotation, the poloidal turbulence flow near the edge reverses prior to the L-H transition, generating a significant poloidal flow shear that exceeds the measured turbulence decorrelation rate. This increased poloidal turbulence velocity shear may facilitate the L-H transition. No such reversal is observed in high rotation plasmas. This reduced power threshold at lower toroidal rotation may benefit inherently low-rotation plasmas such as ITER.

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